ARM 17.30.632:
Selenium Standards for Lake Koocanusa & Kootenai River

Overview of procedural and technical process for standard development

HJ 37 Special Committee

January 27, 2022

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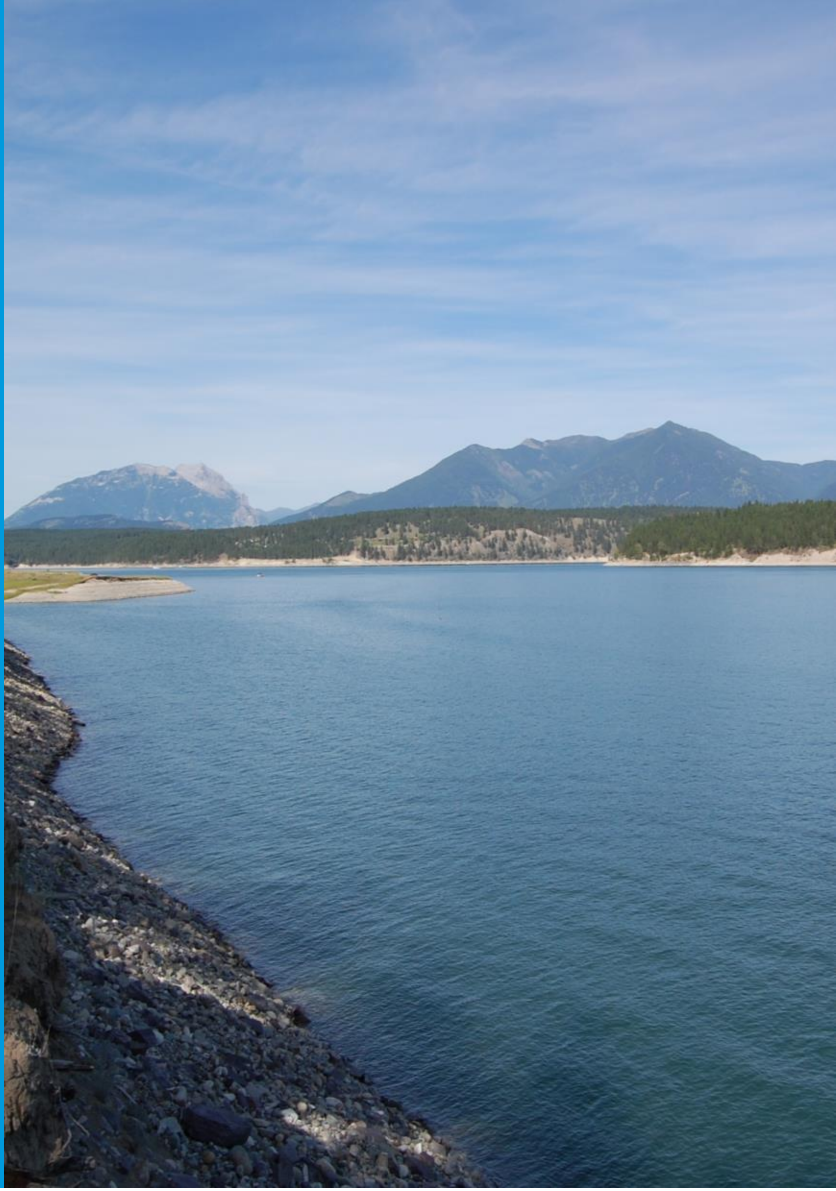
Presentation Outline

- Background and context
- Technical Process
- Rulemaking Process
- Post Rulemaking
- What's next?



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Process: A Transboundary effort

2010

MOUC – Flathead Valley

Coordinated efforts began between BC & MT to address transboundary water quality

2012

Koocanusa Listed for Se

2013

BC Ministerial Order

Remediate water quality effects of past mining activities and guide environmental management of future mining activities in the Elk Valley, including Lake Koocanusa

2015

LKMRWG

Bi-national working group established

2016

EPA updates national Se guidelines

2015-2020

MT & BC Se standard development

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LKMRWG Objective

- LKMRWG identified selenium as the critical and immediate environmental priority
- Establish a selenium technical subcommittee to identify if the BC guideline of 2 µg/L is protective of the beneficial use. If not, what is the appropriate standard?
- One lake one number to protect the beneficial uses

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SeTSC

Selenium Technical Subcommittee (SeTSC)

- State and Provincial co-chairs
- Tribal and First Nations technical representatives
- Federal (EPA, USFWS, USGS)
- Academia (University of Saskatchewan)
- Consulting Co. (Windward Environmental)

Recognize the problem & identify objective(s)

Conceptual Model Framework (USGS report 2017)

Supplemental targeted Data Collection

Ecosystem scale modeling (USGS)

DEQ and BC ENV solicit recommendations from SeTSC and MRC (LKMRWG)

DEQ and BC ENV make final decisions on selenium standards/objectives

How did it happen?

- Six years of coordination
- Engaged Working Group
- Expertise and dedication from leading selenium experts in the US and Canada
- Coordinated transboundary data sharing and data collection
- Robust public website
- Public meetings held in Montana beginning in 2015

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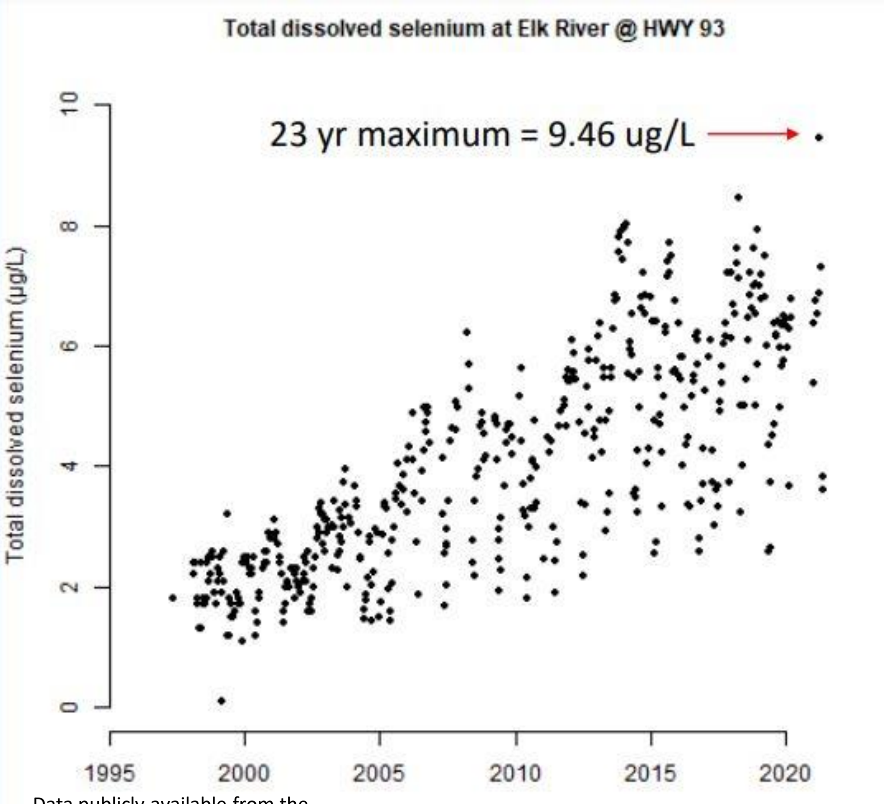
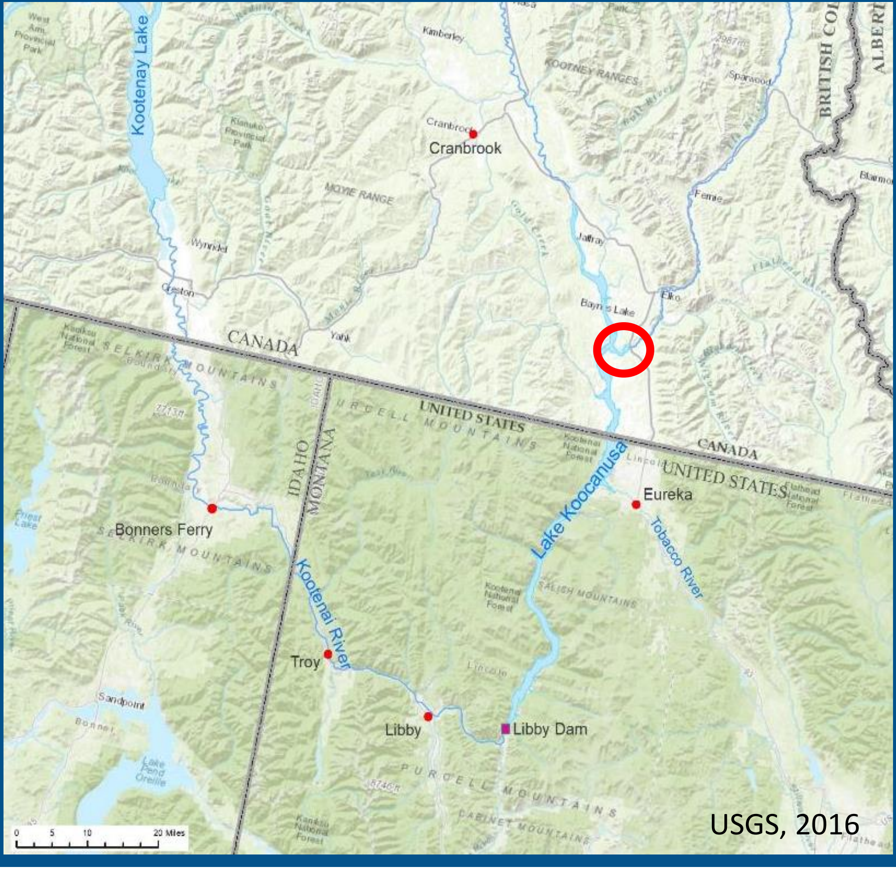
Identifying the Problem

Selenium concentrations have been increasing in the Elk River, BC, a tributary to Lake Koocanusa



Data publicly available from the Government of Canada

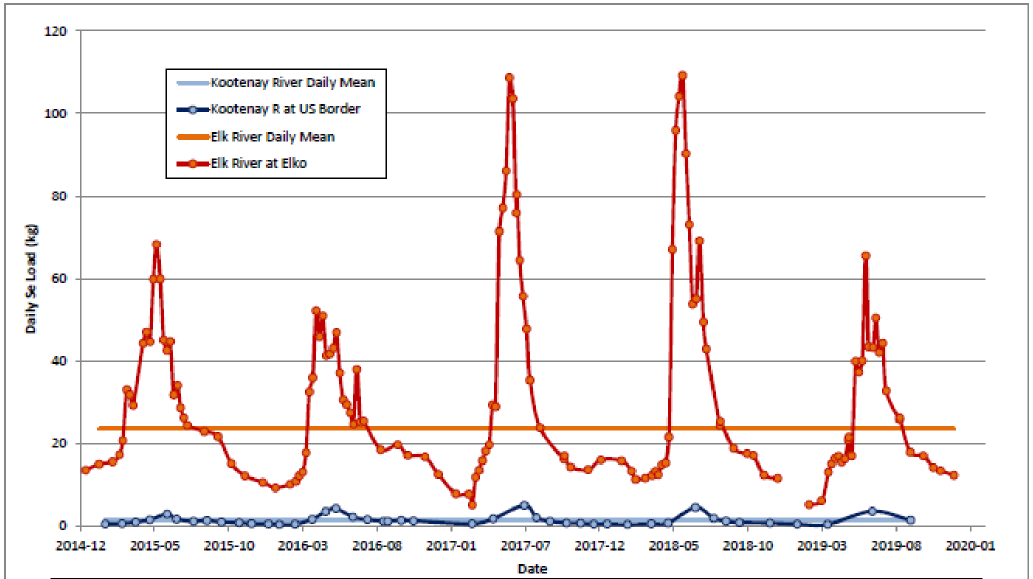
USGS, 2021



USGS, 2016

Selenium Source

- 95% of Se entering Lake Koocanusa, BC is from the Elk River
- MT tributaries to Lake Koocanusa were sampled in 2016 and 2021 with the greatest concentration recorded 0.077 µg/L (very low level)



Notes:
1. To allow for direct comparison of the mean load, The 'Elk River Daily Mean' represents the mean of Elk River load concurrent with the Kootenay River sampling dates, and does not represent the true mean of the entire Elk River dataset.
2. Estimated daily selenium load at "Kootenay River at US Border" exlcudes selenium load originating from the Elk River upstream of Elko.
3. Selenium concentrations were measured at the Elk River at Elko and Kootenay River at Fenwick. Selenium loads were calculated uses these data and the flow scaling values presented in Table 1.

Disclaimer from BC-ENV: the values presented were calculated and incorporate scaled flow values, and therefore do include some uncertainty.

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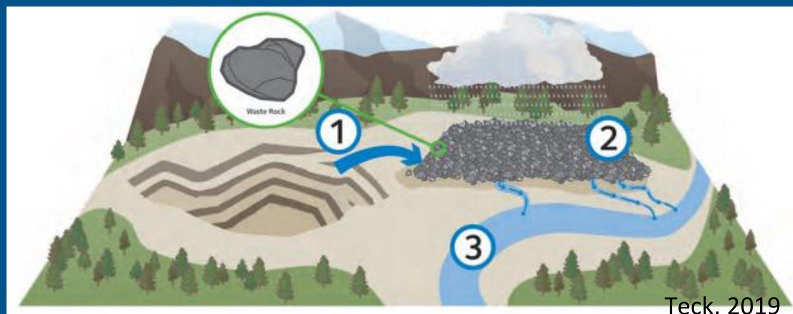
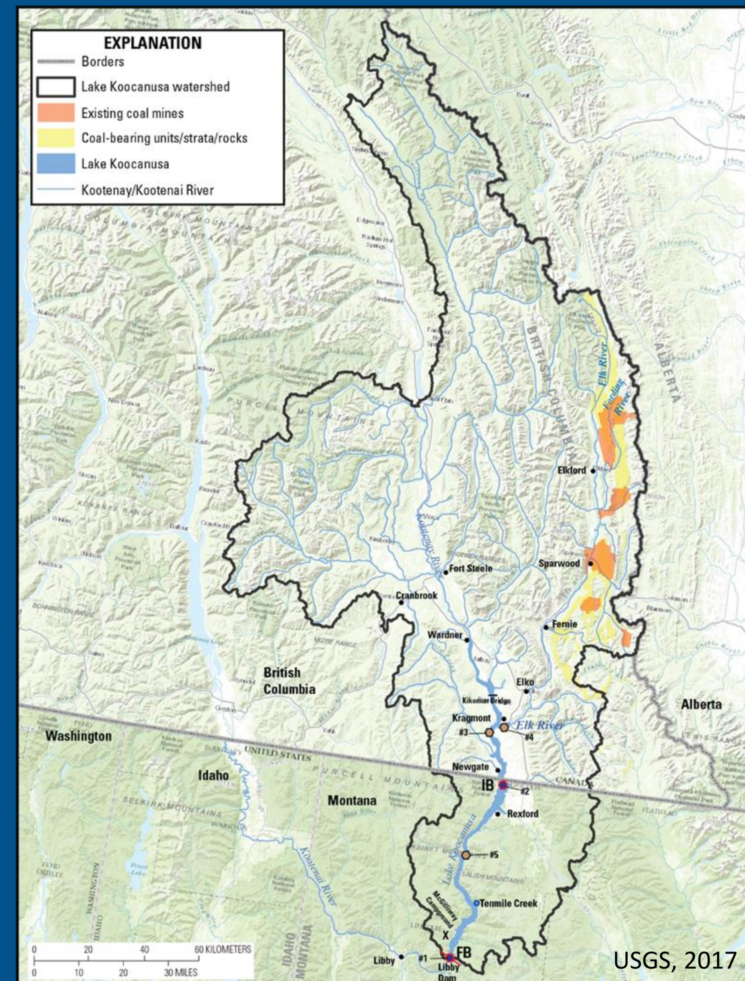
Selenium Source



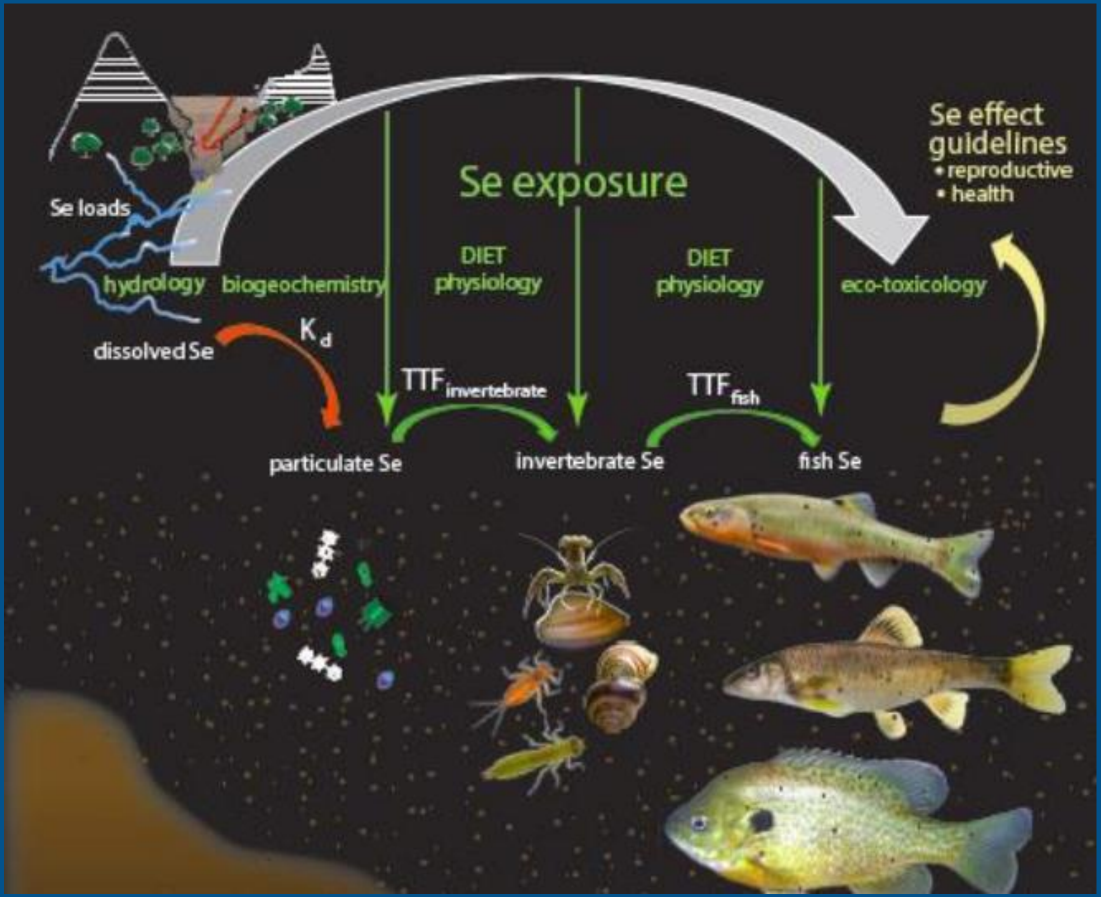
Teck, 2019



USGS, 2017

Selenium exposure pathway

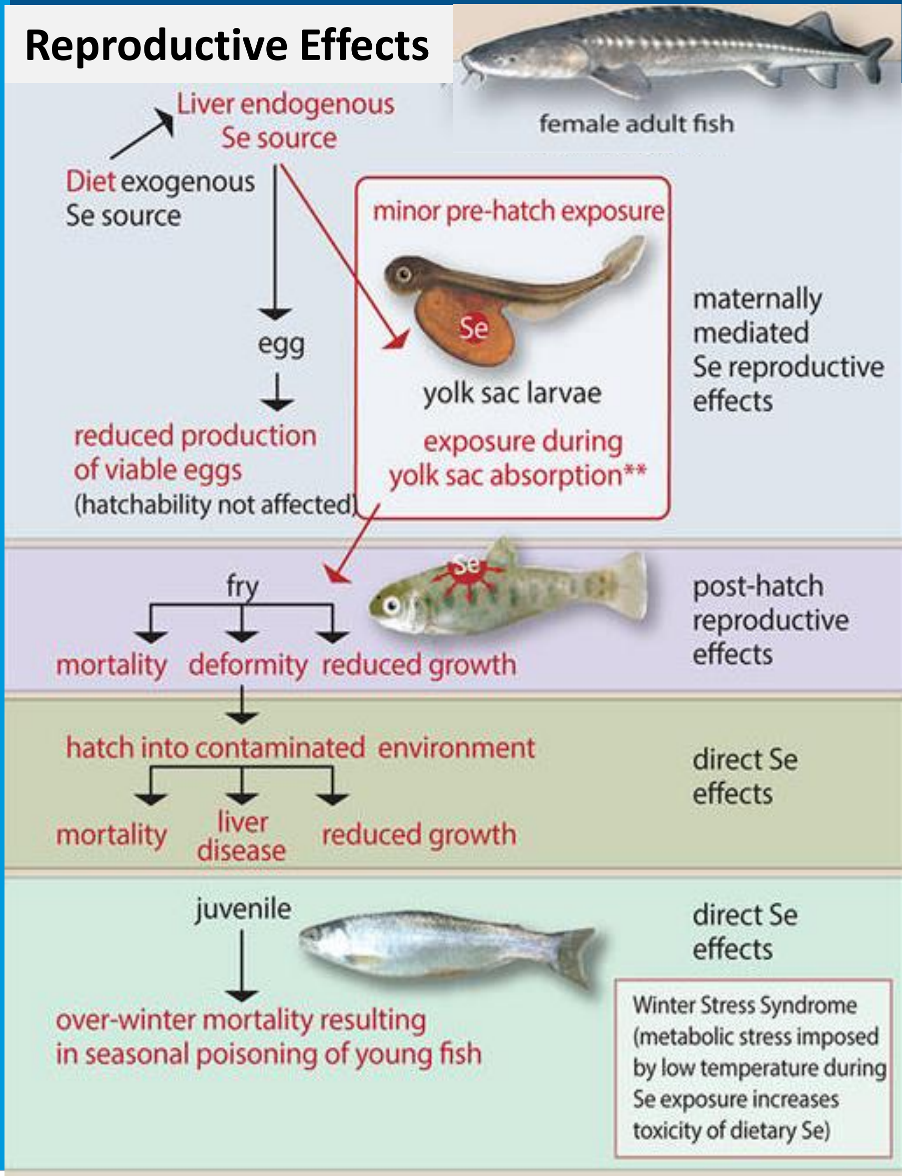
Reservoirs and rivers process selenium differently requiring lakes/reservoirs to have a lower Se standard than rivers



Toxicological Effects

- Reduced production of viable eggs
- Reduced growth
- Mortality or deformity
- Altered liver enzyme function
- Winter Stress Syndrome

- Deformities have not been documented in Lake Koocanusa



Data Collection

DEQ BC ENV USGS Teck

FWP USACE USFWS

- Water chemistry
- Dissolved Se
- Se speciation
- Particulate Se
- Sediment Se
- Periphyton Se
- Invertebrate Se
- Zooplankton Se
- Fish muscle Se
- Fish whole body Se
- Fish egg/ovary Se
- Fish food habits
- Bird egg Se

Selenium Modeling

Model Inputs:

- Fish-tissue Se target (mg/kg dw)
- Food Web
- TTF & bioavailability
- Kd (Suspended Se/dissolved Se)

Peer-reviewed MODEL
Presser & Luoma 2010)

Protective Candidate Criteria (µg/L)

A Methodology for Ecosystem-Scale Modeling of Selenium

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‡John Muir Institute of the Environment, University of California, Davis, California 95616, USA

(Submitted 18 August 2009; Returned for Revision 12 February 2010; Accepted 26 May 2010)

ABSTRACT
The main route of exposure for selenium (Se) is dietary, yet regulations lack biologically based protocols for evaluations of risk. We propose here an ecosystem-scale model that conceptualizes and quantifies the variables that determine how Se is processed from water through diet to predators. This approach uses biogeochemical and physiological factors from laboratory and field studies and considers loading, speciation, transformation to particulate material, bioavailability, bioaccumulation in invertebrates, and trophic transfer to predators. Validation of the model is through data sets from 29 historic and recent field case studies of Se-exposed sites. The model links Se concentrations across media (water, particulate, tissue of different food web species). It can be used to forecast toxicity under different management or regulatory proposals or as a methodology for translating a fish-tissue (or other predator tissue) Se concentration guideline to a dissolved Se concentration. The model illustrates some critical aspects of implementing a tissue criterion: 1) the choice of fish species determines the food web through which Se should be modeled, 2) the choice of food web is critical because the particulate material to prey kinetics of bioaccumulation differs widely among invertebrates, 3) the characterization of the type and phase of particulate material is important to quantifying Se exposure to prey through the base of the food web, and 4) the metric describing partitioning between particulate material and dissolved Se concentrations allows determination of a site-specific dissolved Se concentration that would be responsible for that fish body burden in the specific environment. The linked approach illustrates that environmentally safe dissolved Se concentrations will differ among ecosystems depending on the ecological pathways and biogeochemical conditions in that system. Uncertainties and model sensitivities can be directly illustrated by varying exposure scenarios based on site-specific knowledge. The model can also be used to facilitate site-specific regulation and to present generic comparisons to illustrate limitations imposed by ecosystem setting and inhabitants. Used optimally, the model provides a tool for framing a site-specific ecological problem or occurrence of Se exposure, quantify exposure within that ecosystem, and narrow uncertainties about how to protect it by understanding the specifics of the underlying system ecology, biogeochemistry, and hydrology. Integr Environ Assess Manag 2010;6:685–710. © 2010 SETAC

Keywords: Selenium Food web Bioaccumulation Site-specific ecological exposure Ecosystem-scale

Original Research

INTRODUCTION

Effects from Se toxicity have proven dramatic because of extirpations (i.e., local extinctions) of fish populations and occurrences of deformities of aquatic birds in impacted habitats (Skorupa 1998; Chapman et al. 2010). The large geologic extent of Se sources is connected to the environment by anthropogenic activities that include power generation, oil refining, mining, and irrigation drainage (Presser, Piper, et al. 2004). Toxicity arises when dissolved Se is transformed to organic Se after uptake by bacteria, algae, fungi, and plants (i.e., synthesis of Se-containing amino acids de novo) and then passed through food webs. Biochemical pathways, unable to distinguish Se from S, substitute excess Se into proteins and alter their structure and function (Stadtman 1974). The impact of these reactions is recorded most importantly during hatching of eggs or development of young life stages. Thus, the reproductive consequences of maternal transfer are the most direct and sensitive predictors of the effects of Se (Heinz 1996).

Each step in this sequence of processes is relatively well known, but the existing protocols for quantifying the linkage between Se concentrations in the environment and effects on animals have orders of magnitude of uncertainties. Conventional methodologies relate dissolved or water-column Se concentrations and tissue Se concentrations through simple ratios (i.e., bioconcentration factor, BCF; bioaccumulation factor, BAF), regressions, or probability distribution functions (DuBowy 1989; Peterson and Nebeker 1992; McGeer et al. 2003; Toll et al. 2005; Brix et al. 2005; DeForest et al. 2007). None of these approaches adequately accounts for each of the important processes that connect Se concentrations in water to the bioavailability, bioaccumulation, and toxicity of Se.

In this paper, we present an ecosystem-scale methodology that reduces uncertainty by systematically quantifying each of the influential processes that links source inputs of Se to toxicity. In particular, we emphasize a methodology for relating dissolved Se to bioaccumulated Se. The methodology allows us to 1) model Se exposure with greater certainty than previously achieved through traditional approaches that skip steps, 2) explain or predict Se toxicity (or lack of toxicity) in site-specific circumstances, and 3) translate proposed Se guidelines among media under different management or regulatory scenarios.

Important components of the methodology are 1) empirically determined environmental partitioning factors between water and particulate material that quantify the effects of dissolved speciation and phase transformation, 2) concentrations of Se in living and nonliving particulates at the base

All Supplemental Data may be found in the online version of this article.
* To whom correspondence may be addressed: tpresser@usgs.gov
Published online 3 June 2010 in Wiley Online Library (wileyonlinelibrary.com).
DOI: 10.1002/ieam.101

$$C_{target} = \frac{C_{tissue\ criterion\ element}}{TTF^{composite}\ X\ K_d}$$

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Recognize the problem & identify objective(s)

Conceptual Model Framework (USGS report 2017)

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DEQ and BC ENV solicit recommendations from SeTSC and MRC (LKMRWG)

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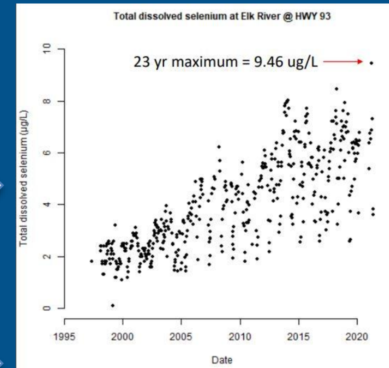

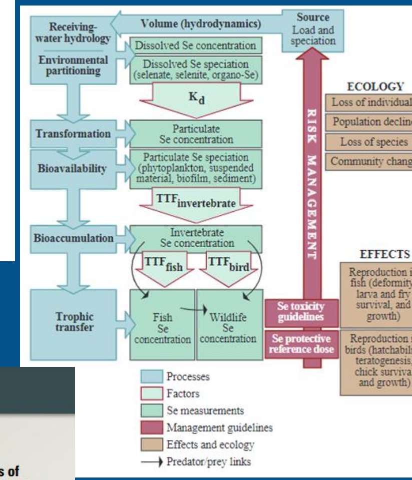

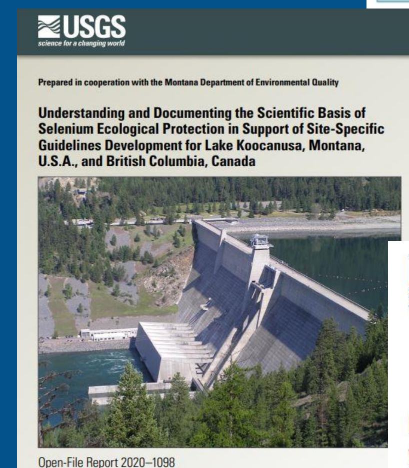
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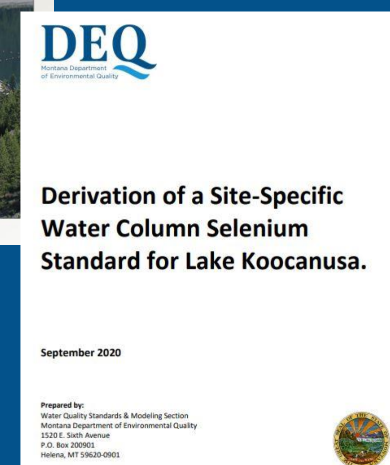
Prepared in cooperation with the Montana Department of Environmental Quality

Understanding and Documenting the Scientific Basis of Selenium Ecological Protection in Support of Site-Specific Guidelines Development for Lake Koocanusa, Montana, U.S.A., and British Columbia, Canada

Open-File Report 2020–1098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Montana Department of Environmental Quality

Derivation of a Site-Specific Water Column Selenium Standard for Lake Koocanusa.

September 2020

Prepared by:
Water Quality Standards & Modeling Section
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Helena, MT 59620-0901

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Lake Koocanusa & Kootenai River Standards

Media Type	Fish Tissue		Water Column
Criterion Element	Egg Ovary	Whole Body or Muscle	Monthly Average Exposure
Magnitude	15.1 mg/kg dw	8.5 mg/kg dw or 11.3 mg/kg dw	Lake Koocanusa- 0.8 µg/L Kootenai River- 3.1 µg/L
Duration	Instantaneous measurement	Instantaneous measurement	30 days
Frequency	Not to be exceeded	Not to be exceeded	Not more than once in three years on average

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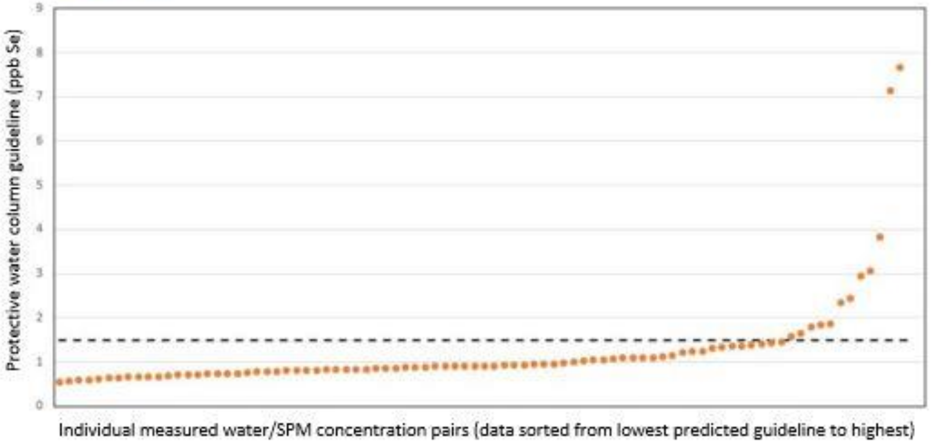
Comments on 0.8 µg/L vs. 1.5 µg/L

National criteria

- 1.5 may be under/over protective for some sites across the US
- Site-specific criteria may be necessary



Model results

- Results from DEQ selected scenario:
  - 85% of results ≤ 1.5 µg/L

Through this modeling effort it was the objective to consider ecologically significant species and the long-term protection for fish in all parts of the reservoir including those with the most sensitive food webs

- 1.5 µg/L does not meet the protection goals
- 0.8 µg/L meets these objectives and protects the beneficial use

Process: MAPA

DEQ RULE MAKING PROCESS

1. Initiate rulemaking at Board of Environmental Review
2. File notice of rulemaking in Montana Administrative Register
3. Notice of rulemaking published in Montana Administrative Register

   10 Days after filing
4. Notify interested parties of rulemaking within 3 days
5. Hold a public hearing, and comment period, no sooner than 20 days after publication
6. Close public comment period no sooner than 28 days after publication
7. Final rule adoption at Board of Environmental Review
8. File notice of adoption in Montana Administrative Procedure Act (MAR)

   No sooner than 30 days or later than 6 months after notice
9. Notice of adoption published in MAR (effective the day after publication)

   10 Days after filing, then submit to EPA for approval

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Post rule making developments EPA Approval

- ARM 17.30.632 adopted on Dec 24, 2020
- MT submitted those standards and record to EPA for approval under the CWA.
- Approved by EPA in February 2021
- Standards remain the applicable standard for CWA purposes until an alternative standard is submitted and approved by EPA
- Approval is based on sound science for protection of the beneficial use

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Post rule making developments LKMRWG and BC update

- LKMRWG met in Nov 2021– shared agency updates and 2021 monitoring updates from multiple parties collecting data
- BC shared their proposed water quality objective

Egg/ovary (mg/kg dw)	Whole Body (mg/kg dw)	Muscle (mg/kg dw)	Water Column (µg/L)	Jurisdiction
11.0	5.2	5.6	0.85	BC – Lake Koocanusa
15.1 15.1	8.5 8.5	11.3 11.3	0.8 3.1	MT – Lake Koocanusa MT – Kootenai River
15.1	8.5	11.3	3.1	ID – Kootenai River

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Post rule making developments BER Stringency Petition

- Teck Coal and Lincoln County Commissioners filed separate (but now combined) petitions to the BER stating the Lake K Se standard is more stringent than the federal standard
- The petition requests the newly appointed Board revisit the previous Board's decision in 2020, whereby the Board determined the standard is no more stringent than federal
- The State opposes the petition on the basis the standards are no more stringent than federal criteria

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Post rule making developments
Ongoing Monitoring

- Ongoing monitoring efforts on Lake Koocanusa continue by federal partners and MT Fish Wildlife & Parks
  - 2020 showed the highest concentrations of Se in fish tissue on record, some samples more than doubling the standard
  - 2021 showed the highest weekly average recorded by USGS at the International Boundary (1.95 µg/L)

USGS high frequency monitoring station located at the International Boundary

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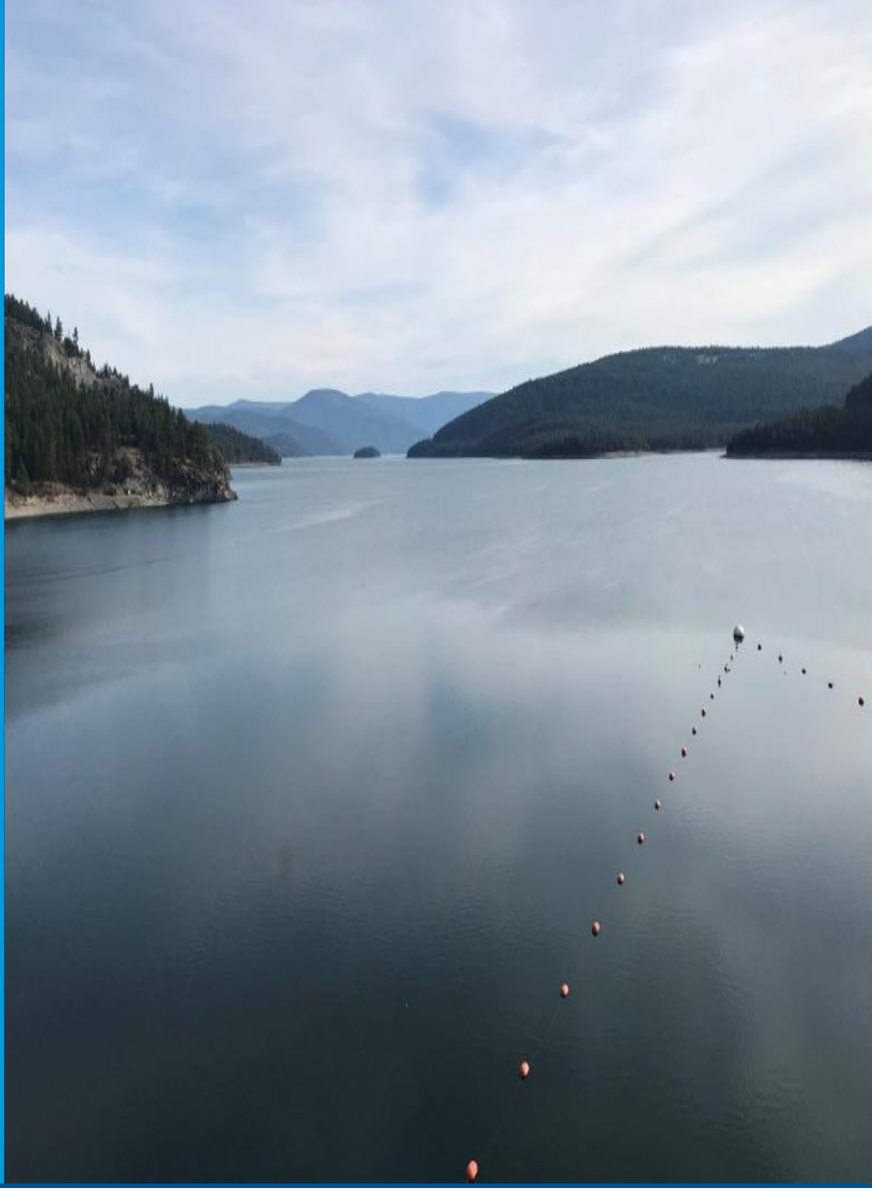
What’s next?

- Takeaways
- DEQ offers to:
  - Follow up with presentations on any of the data, modeling efforts, or process
  - Provide additional materials
  - Work with project partners to answer any
    remaining questions
  - Provide input as the committee requests on their workplan



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